DEFENSE STANDARDIZATION PROGRAM

CASE STUDY

Obsolescence Management for *Virginia*–Class Submarines

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This case study describes how the Navy resolves technology obsolescence issues that directly affect the operational capability, safety, and reliability of almost every major electronics system on *Virginia*–class submarines. To date, the Navy has solved approximately 1,000 obsolescence issues. The solutions have resulted in more than $96 million in cost avoidance.

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Obsolescence Management for *Virginia*–Class Submarines

BACKGROUND

Designed by General Dynamics Electric Boat, the *Virginia* class (or SSN-774 class) of submarines is being built jointly under a teaming arrangement between General Dynamics, Electric Boat Corporation in Groton, CT, and Northrop Grumman, Newport News Shipbuilding in Newport News, VA. The *Virginia* class is the first class of U.S. submarines designed for a broad spectrum of open-ocean and littoral missions around the world. These submarines have improved stealth, sophisticated surveillance capabilities, and special warfare enhancements to meet the Navy's multimission requirements. Those missions include antisubmarine and surface ship warfare; covert long-term surveillance of land areas, littoral waters, or other sea forces; delivery and support of special operations forces; and mine delivery and minefield mapping. With enhanced communications connectivity, the *Virginia*–class submarines also can provide important battle group and joint task force support, with full integration into carrier battle group operations.

The *Virginia*–class submarines incorporate several innovations. Instead of periscopes, the subs have two extendable photonics masts outside the pressure hull. Each mast contains several high-resolution cameras with light-intensification and infrared sensors, an infrared laser range finder, and an integrated electronic support measures system that provides full-spectrum radar processing, automatic threat warning, and situation assessment. Signals from the masts' sensors are transmitted through fiber-optic data lines through signal processors to the control center. High data-rate, multiband satellite communications systems allow simultaneous communication at an extremely high frequency. The state-of-the-art sonar system has more processing power than all legacy sonar systems combined to process and distribute data received from its spherical bow array, high-frequency array suite, dual towed arrays, and flank array suite.

These and other design features make these new submarines the most flexible in the fleet. Through the incorporation of modular design techniques, open architecture, and integrated commercial off-the-shelf (COTS) electronics components, the *Virginia*–class submarines have the capability to respond quickly to changing missions and threats, as well as the capability to continually upgrade to state-of-the-art technologies. In short, these new submarines are designed to enable the Navy to carry out its assigned missions well into the 21st century.

Problem

Although the *Virginia*–class submarine is designed for maximum flexibility, allowing for technological insertion and innovation over the long term, obsolescence issues, particularly with electronics systems, arise because of

- the amount of time between the installation of the electronics systems on a ship module and the delivery of the ship to the Navy,
- the amount of time between the start of construction of the first submarine and the delivery of the last one with the same equipment configuration,
- the submarines' long service life, and
- the rapid advance of COTS electronics technology.

The Navy currently has contracted for the acquisition of 18 *Virginia*–class submarines (SSN-774 through SSN-791). Construction of the SSN-774 began in September 1999, and delivery of the SSN-791 is expected in 2019. The Navy may procure an additional 12, for a total of 30 submarines, by 2025. Not only is the construction program for these submarines spread over some 25 years (depending on the number ultimately procured), but the submarines are designed to remain state of the practice for their entire service life—30 to 40 years—through the introduction of new systems and payloads.

The platform's extended construction times and long service life contrast sharply with the extremely short times that electronics technology remains state of the art. For example, microprocessor speed doubles about every 18 months and fiber-optic transmission capacity doubles in fewer than 8 months. Because of the rapid advances, new technology quickly becomes obsolete.

A key concern is the risk of the Navy being left behind as manufacturers introduce new products based on new technology and discontinue production and support of older items included in the initial designs of the various electronics systems. Obsolescence issues impact both construction and follow-on support of the submarines and their electronics systems, and they can result in increased cost.

To ensure that the submarines remain up to date, the program office in charge of the *Virginia*–class acquisition (PMS 450), a component of the Naval Sea Systems Command (NAVSEA), established the *Virginia*–Class Submarine Technology Refresh Integrated Product Team (TR IPT) in 2001. PMS 450 charged the team with developing low-cost solutions to obsolescence issues as they arise.

The multidisciplinary team consists of engineers and logisticians from PMS 450, Electric Boat, multiple system manufacturers, government in-service engineering agents (ISEAs), participating manager program offices, both divisions of the Naval Undersea Warfare Center (NUWC), and the Naval Inventory Control Point. The IPT is led by NUWC, Keyport Division, in Keyport, WA.

Approach

The traditional approach to resolving obsolescence issues—or managing technology changes—related to electronics systems is to redesign and integrate new items as issues arise, or to procure large quantities of items at the circuit-card level (after estimating reliability and projected demand) to ensure the availability of a lifetime supply of those items. The traditional approach is costly and time-consuming due to the cost and time of design and the cost of having the platform (submarine, aircraft, or other system) spend months in a depot for upgrades.

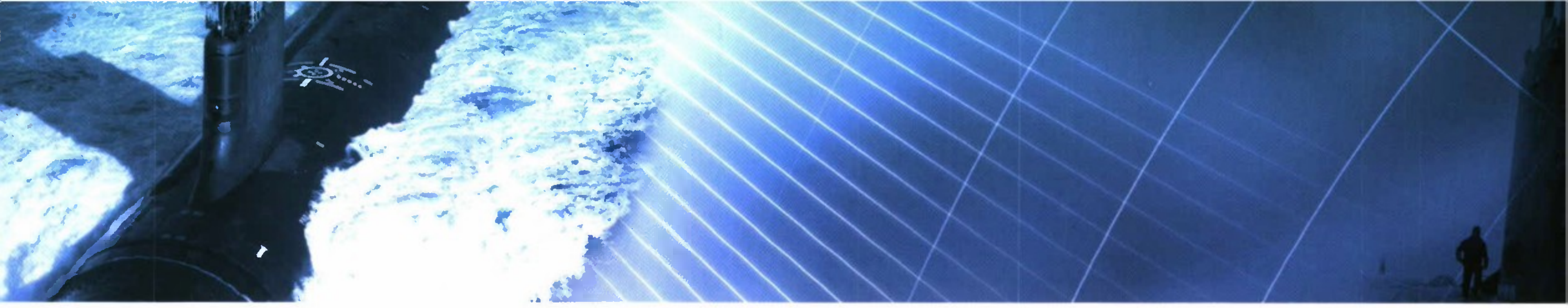
The *Virginia*-class TR IPT has taken a different approach, one that was enabled by the *Virginia*-class program office's (PMS 450) decision, at the onset of the *Virginia*-class acquisition program, to use modular design techniques, open architecture, and COTS components, as follows:

- The use of modular construction means that numerous modules are built independently, by different contractors, and then joined with the hull sections to create the ship, much like modular houses are built. The module of particular concern to the TR IPT is the command and control systems module, which has two levels, is 60 feet long, and weighs some 200 tons. Electric Boat is building this module, integrating COTS command, control, communications, computer, and intelligence systems designed and built by various manufacturers.
- The decision to use open architecture and COTS components was based largely on the success of the groundbreaking Acoustic-Rapid COTS Insertion (A-RCI) program. Open architecture is used to develop information systems based on COTS technologies and takes advantage of commercial standards, providing open, nonproprietary solutions that better leverage innovations, regardless of the source. In other words, open architecture isolates the computing infrastructure from the application, allowing rapid change and insertion of new capability.

The approach established by the TR IPT is proactive; in other words, the team identifies obsolescence issues affecting the *Virginia*-class submarines before they impact ship construction and develops timely solutions. The TR IPT's approach has the following elements:

- Identify obsolescence issues early using the Obsolescence Management Information System (OMIS™) or via vendor monitoring efforts
- Notify stakeholders that an issue has been identified
- Identify all systems affected
- Select a solution
- Execute the solution
- Measure and report results.

To ensure consistency and repeatability of results, the *Virginia*-class Tech Refresh IPT has had a formal Tech Refresh Plan in place since January 2006, which also meets all Diminishing Manufacturing Sources and Material Shortages (DMSMS) plan requirements, and a new project plan for managing DMSMS issues is created annually. The team also



has had a signed standard operating procedure and charter since 2003. Defined processes are followed in order to proactively identify and solve obsolescence issues as early as possible in the system life cycle. When an obsolescence issue is identified from any source, such as through active monitoring, or from an end-of-life notice, a Tech Refresh Issue (TRI) case is generated and tracked until final resolution is reached.

Figure 1 illustrates a high-level process for resolving *Virginia*–class obsolescence issues. Not only is the process well defined and mature, but it is followed throughout PMS 450.

The TR IPT uses weekly teleconferences to manage and track the progress of TRIs through the platform and system evaluation/resolution process. Semiannual platform-level TR IPT meetings are held to formalize communications of platform areas of concern, assess the status of TRI resolutions that involve design work, and stimulate discussion and system technology issue reporting.

Identify Obsolescence Issues

Continual market surveillance is a key feature of the IPT's proactive approach. One aspect of the program is to obtain bills of material from commercial product original equipment manufacturers (OEMs) and actively monitor the status of the parts in NUWC Keyport's OMIS. OMIS is populated with microcircuit-level information for the circuit cards that make up various *Virginia*–class electronic systems. After this information is gathered, OMIS conducts a weekly health check of these *Virginia*–class piece parts using an industry database. Using OMIS, microcircuit experts at NUWC Keyport, in collaboration with system designers, assess the impact of microcircuit production discontinuance plans. OMIS provides intelligence regarding *Virginia*–class designs often a year in advance of actual microcircuit discontinuance. This offers the greatest degree of freedom to address problems at the lowest level, usually at great program savings. OMIS contains a variety of functions for use in resolving these low-level issues and future planning for the aggregate of all microcircuits associated with the *Virginia* class. In addition, the shipbuilder is responsible for monitoring the health of the commercial electronics used in the system designs that it provides. The repository of parts it monitors is updated with new information as technology refreshes occur.

Notify Stakeholders

The first step to resolving obsolescence issues is an impact assessment for the users of a specific component. Because the *Virginia*–class submarine had commonality initiatives and the systems are primarily designed using COTS electronics, many of the parts used in the system designs are common. Therefore, many systems can be affected by a single obsolescence issue.

Identify All Systems Affected

To ensure that it identifies all of the affected systems, the TR IPT shares every new obsolescence

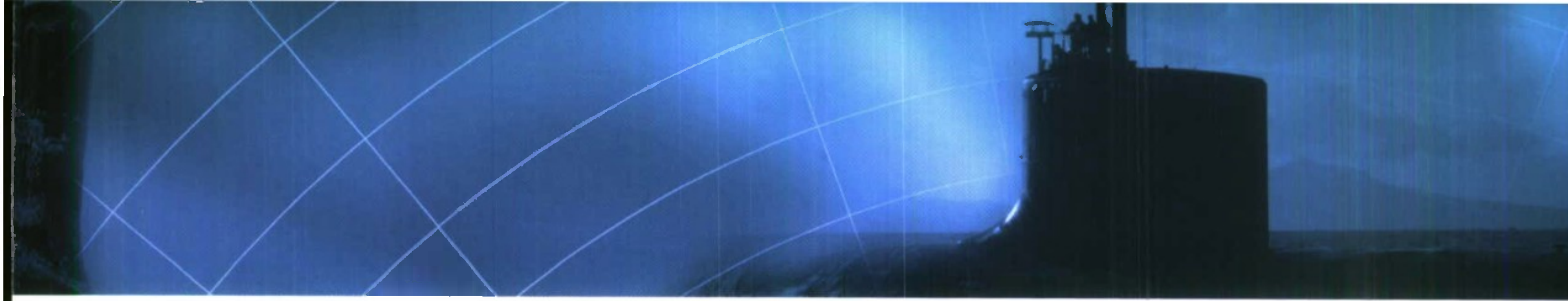
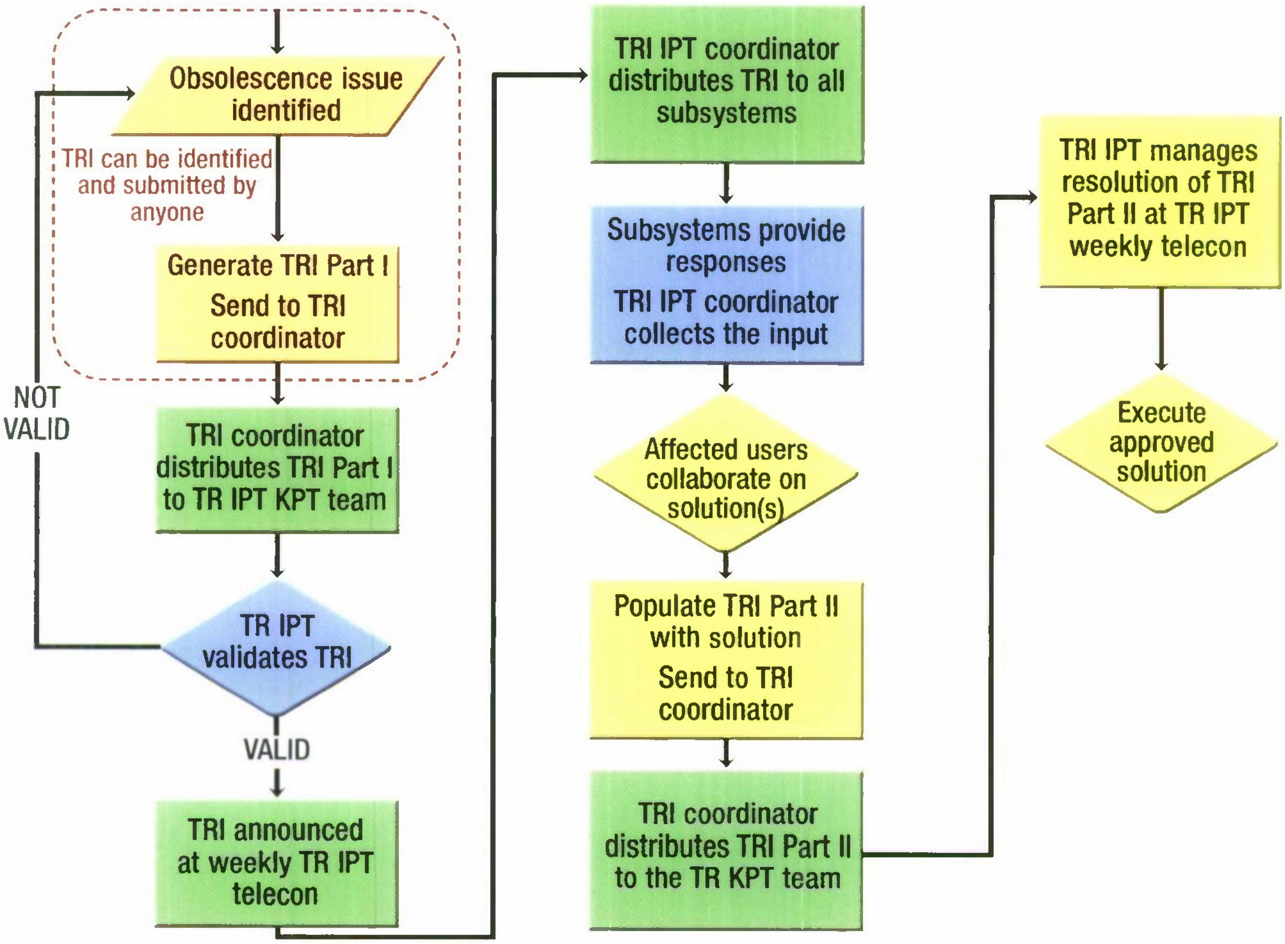


Figure 1. High-Level Process Used to Address Virginia-*Class Obsolescence Issues*



issue with the *Virginia*–class community through a process known as the platform impact assessment. The notification process allows the team to identify all of the affected systems on the platform and then to apply a common solution. As a result, rework is minimized. The process involves collaboration among NUWC Keyport Division, NUWC Newport Division, and Electric Boat, as well as system prime contractors and government and private-sector system designers. In addition, the team shares the TRIs with the ISEAs for the affected systems. All stakeholders notify the IPT whether or not the issue will affect any of the electronic systems they provide on the *Virginia*–class submarine. The team also shares the TRIs, through a secondary distribution and notification process, with others who can assess the issue for its possible impacts on other systems or platforms for which the *Virginia*–class TR IPT does not have direct responsibility, for example, NAVSEA 08 and the Space and Naval Warfare Sys-

tems Command. Roughly 60 individuals are notified of each *Virginia*–class–related obsolescence issue.

Select a Solution

The central management function of the *Virginia*–Class Tech Refresh IPT consists of several steps that address obsolescence. Once all users are identified, system engineers for each system propose obsolescence resolutions that are consolidated as much as practical given unique system requirements. The TR IPT coordinates and collaborates with the stakeholders to evaluate the alternative solutions. The team meets regularly with OEMs and with corporate and government system representatives to discuss the obsolescence issues and to plan strategies for mitigating those issues. The TR IPT also coordinates obsolescence mitigation with other planned designed changes and subsystem upgrades. Resolutions are vetted by IPT staff members and functional experts for the following:

- Technical appropriateness
- Cost effectiveness
- Conformance with *Virginia*–class acquisition plans and contracts
- Logistics and support needs
- *Virginia*–class construction requirements.

Solution options are listed as follows:

- Original component (CCA/module level)
  - Existing stock
  - Extend manufacturing
  - Reclamation
- Technology refresh design longevity (microcircuit level)
  - Existing OEM stock (microcircuit OEM)
  - Alternate microcircuit form, fit, and function (FFF) item identified by CCA/module OEM
  - Life-of-type (LOT) buy of the microcircuit (ensures continued production at the CCA/module level)
- Substitute or FFF replacement (CCA/module level)
- Alternate source (CCA/module level)
- LOT buy or bridge buy (CCA/module level)
- Aftermarket source (CCA/module level)
- Extended repair (CCA/module level)
- Emulation (CCA/module or microcircuit level)
- Reverse engineering (CCA/module level)
- Redesign (minor)
- Redesign (major).

If the solution to a particular obsolescence issue is to buy spares, the TR IPT works with NUWC Newport—the designated *Virginia*–class reliability, availability, and maintainability authority—to estimate life-cycle spares needed, using a Readiness-Based Sparing model. This scientific, repeatable model calculates both shore spares and on-board repairs parts (OBRPs), using a continuous Poisson distribution with a confidence level of 90 percent, for the known mean time between failures, reparability, and duty cycle and for the support window established for *Virginia*–class hulls. Considering the results of the calculations, the team recommends the

quantities of spares and OBRPs to be purchased.

Execute the Solution

The TR IPT is chaired by a PMS 450E staff member who moderates overall operation of the IPT; manages issue resolutions; sponsors, as needed, PMS 450 authorizing correspondence; and manages tasking/funding for organizations that support it. The TR IPT has the ability to resolve certain solutions within predetermined budget constraints. If a solution falls outside of that window, it is presented to PMS 450 for authorizing funding and contract actions through the Navy's Supervisor of Shipbuilding, Conversion and Repair.

To execute the chosen solution, resources are combined to determine a platform-wide resolution, funding is consolidated, and procurements are combined, resulting in cost savings due to economies of scale.

After the issue is resolved, the TR IPT closes the TRI and updates OMIS, which users can access to obtain the latest information about system health and obsolescence solutions.

Measure and Report Results

The TR IPT uses the guidance of DSP's SD-22, *Diminishing Manufacturing Sources and Material Shortages: A Guidebook of Best Practices and Tools for Implementing a DMSMS Management Program*, to measure cost avoidance. The team tracks the cost avoidance on every TRI and reports the metric monthly with the cost avoidance for the month, cumulative for the year, and cumulative since program inception.

This reporting enables the *Virginia*-class program office to see the value in continued funding of the obsolescence program.

Benefits

Since the program's inception in October 2001, the TR IPT has opened more than 1,000 TRIs for *Virginia*-class nonpropulsion electronic subsystems. These issues directly affected the operational capability, safety, and reliability of almost every major system on the ship, including fly-by-wire and other safety-of-ship systems. Of those issues, approximately 850 have been resolved, and the remaining issues are being worked. Examples of the *Virginia*-class systems with resolved obsolescence issues are Ship Control, Circuit D, Sonar, Combat Control, Navigation, Photonics, Interior Communications, Weapons Launch Control System, and Impressed Current Cathodic Protection.

To date, the obsolescence resolutions developed by the TR IPT have resulted in some $96 million in cost avoidance. Over $10.1 million in cost avoidance have been achieved so far in FY10 (through July 2010).

Not only has the *Virginia*-class obsolescence program resulted in lowering life-cycle sustainment costs, but it has done so while maintaining operational availability and improving the capabilities of the platform's electronics systems. For example, ear-

ly monitoring of obsolescence issues has allowed the prime integrator to meet many of the OBRP requirements by making timely procurements, thus having positive impact on the platform operational availability. There are other specific cases in which, later in the system life cycle, OBRPs have been forced on the boats in order to increase operational availability. There also have been numerous cases in which stock on-hand as a result of case resolution has allowed the shipbuilder to construct OBRPs to meet the newly defined requirement.

Lessons Learned

Crucial to the success of the *Virginia*–class obsolescence program was the submarine's design using modules, open architecture, and COTS components. The following are the key lessons learned from the *Virginia*–class program to proactively resolve technology obsolescence issues:

- *Formalize the obsolescence program.* The TR IPT was established early in the *Virginia*–class acquisition program and reports regularly to senior leaders. The team has had a signed standard operating procedure and charter since 2003, and it has had a formal DMSMS plan in place since January 2006. Annually, the TR IPT creates a new project plan for managing obsolescence issues. Because its program is formalized, the IPT can ensure consistency and repeatability of results, enabling it to identify and solve obsolescence issues as early as possible in the system life cycle.
- *Develop strong communication ties with program managers, contractors, OEMs, and other entities that may be affected by obsolescence issues.* Regular communication among all stakeholders fosters effective coordination and cooperation in solving obsolescence issues and implementing upgrades.
- *Establish a process for notifying all stakeholders when an issue is identified.* The notification process developed by the TR IPT allowed it to identify all of the affected systems and then to apply common solutions. As a result, the same obsolescence issue rarely resurfaces, because the effective team communications capture the issue platform-wide the first time it is introduced to the community.
- *Involve all stakeholders in identifying possible solutions to obsolescence issues.* This approach provides a forum for addressing platform impact, commonality, and logistics issues and results in the selection of the best solution for the platform as a whole. For example, stakeholders aware of planned designed changes and subsystem upgrades can share that knowledge with stakeholders whose primary concern is to mitigate an obsolescence issue. Often, older components can be replaced with new, more advanced components, improving overall system performance.